3.4: Galileo Galilei (1564-1642)- The Man Who Saw Further than Anyone

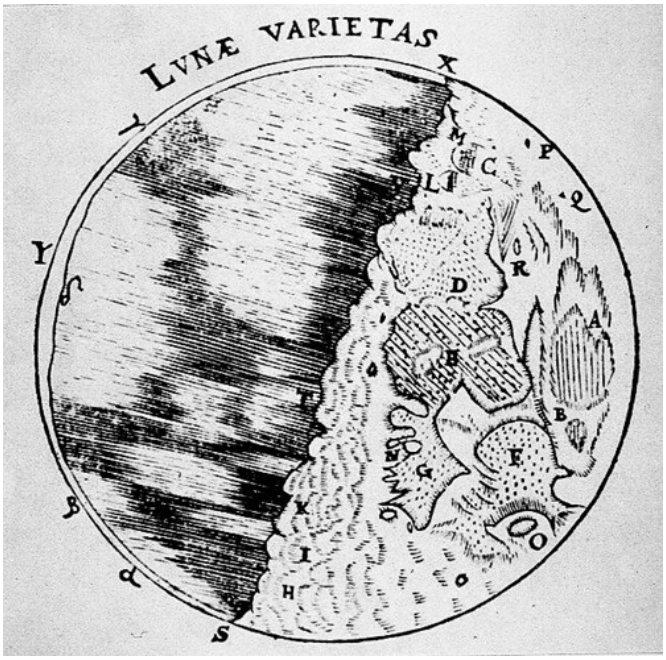
Galileo Galilei

If anyone can be considered the father of the modern scientific method, it would be Galileo Galilei. Galileo's observations changed the way we view our place in the universe. His studies of motion paved the way for Isaac Newton's laws of motion. He was the first astronomer to use a telescope to study the night sky and the first to discover moons orbiting another planet. Through he posthumously vindicated in his advocacy of heliocentrism, his zealous (some might say, arrogant) defense of the Copernican model cost him dearly.

Born in the Duchy of Florence, Galileo initially studied medicine at the University of Pisa, but later switched to mathematics and natural philosophy. While working as a professor of mathematics and astronomy at the University of Padua, Galileo heard of a party novelty invented by a pair of Dutch eyeglass makers that could make distant objects appear closer. Glass makers at the time kept their techniques secret, so Galileo had to teach himself how to grind lenses, using an artillery ball to shape the convex lens.

Eventually, he produced a telescope with several improvements compared to the Dutch invention. He presented his telescope to the leaders of Florence, who immediately saw the military advantage of being able to see incoming ships hours before the arrived at the harbor. They rewarded they with a generous stipend for life.

Galileo next turned his telescope toward the sky. He examined the Moon and, contrary to the conventional wisdom, was not a perfect, smoother sphere, but contained numerous mountains, valleys, and craters. He then studied Jupiter and found four tiny "stars," too faint for the naked eye to see, orbiting Jupiter. He quickly concluded that these were moons that went around Jupiter much like our own moon orbits the Earth. He published his findings in his work *Sidereus Nuncius* (Starry Messenger), which created a sensation. Capitalizing on his newfound fame, Galileo maintained to secure patronage from the powerful Medicci family and returned to live in Florence.



One of Galileo's drawings of the surface of the Moon.

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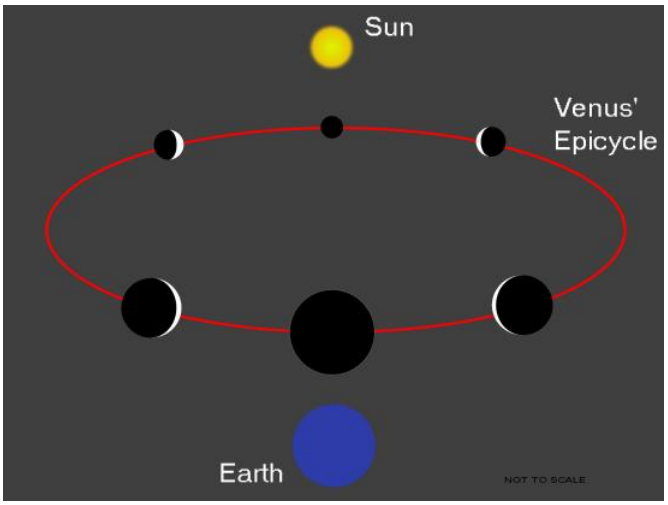
"Jupiter with Galilean moons" by DangerBarrow is licensed under CC BY-NC-ND 2.0;

Galileo continued to gather evidence in favor of the Copernican model, including discovering that the planet Venus exhibited phases much like the Moon did and that the Sun had tiny blemishes or sunspots on its surface. The phases of Venus could not be explained by a geocentric model. In Ptolemy's model, Venus could only have two phases: New and Crescent, not the full set of phases Galileo observe. Also, the existence of sunspots challenged the assumption that the Sun and other heavenly bodies were

perfect and unblemished. When asked by the Grand Duchess of the Medicci family if his findings conflicted with scripture, Galileo simply replied that scripture had been misinterpreted and that the Bible was never intended to be an astronomy textbook.



In a geocentric model, Venus would only appear with two phases: Crescent and New.

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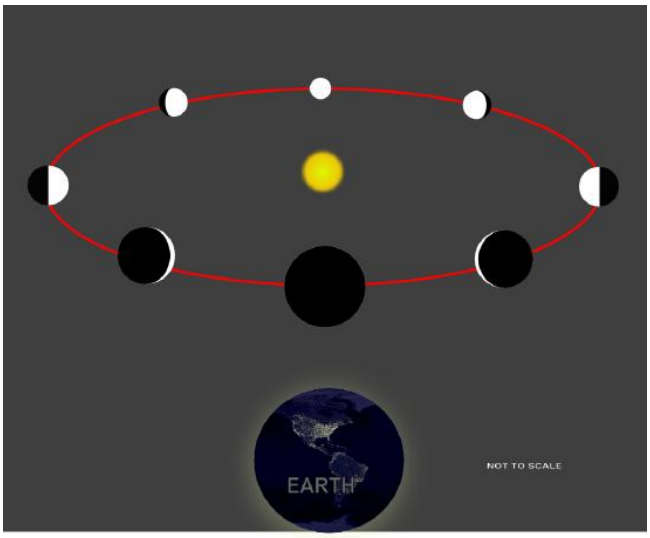


In a heliocentric model, Venus exhibits the same range of phases as the Moon.

Nichalp 09:56, 11 June 2006 (UTC) modified by Sagredo/Public domain;)

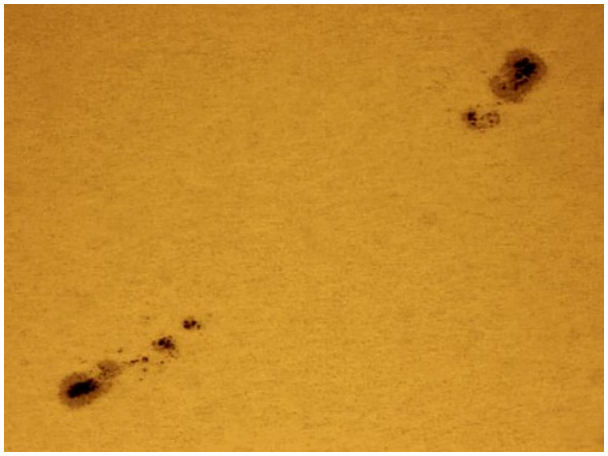
These statements came to the attention of the Grand Inquisitor Cardinal Bellimine, who informed that heliocentrism ran counter to church doctrine and he was forbidden to publish arguments in favor of it without real evidence. Bellimine and the other church leaders pointed to several arguments (besides scriptural) against heliocentrism, including the following:

1. The lack of perception of movement. Why did dropped objects not fly off to the west if the Earth moved?
2. The lack of stellar parallax.
3. Aristotle's view that the heavens were perfect, constant, and circular.

Galileo answered each of those objections. Aristotle believed that all objects tended to go to rest, which is why many assumed that a dropped object would appear to fly off to the West as the Earth movement away from it. Galileo countered with the analogy of a horse rider carrying a ball. If the rider tossed the ball in the air while the horse was at full gallop, the ball continued to travel with the horse and rider as it fell back into his hand. From the rider's perspective, the ball did not fly backwards as Aristotle would have assumed. While Galileo's explanation would later become the foundation for Isaac Newton's First Law of Motion, it failed to convince the inquisitors.

To explain the lack of parallax, Galileo pointed his telescope at the Milky Way. What looked like a whitish cloud stretched across the sky turned out to be made up of countless stars. They only looked like a cloud because they were so far away. While Tycho had believed he had measured the distances to the stars, Galileo demonstrated that many of them were much, much further away than the “greatest astronomer of his age” had though.

To counter Aristotle’s view that the heavens were perfect and constant, Galileo pointed to Tycho Brahe’s study of a supernova to argue that the heavens were not constant. He also argued that mountains and valleys on the Moon and sunspots showed the heavens were not the perfect spheres people had assumed they were for centuries. Also, the fact that Jupiter had moons proved that not everything could orbit the Earth.



The existence of sunspots challenged the assumption that the Sun and other celestial objects were perfect and unblemished.

Despite these points and the phases of Venus, the Churches declared heliocentrism a foolish superstition and Cardinal Bellimine ordered Galileo to cease his advocacy of the heliocentric model. Unable to publish, Galileo continued his observations in hopes of uncovering more evidence to persuade the authorities to reverse their decision.

In 1623, an event occurred that gave Galileo the opportunity he had hoped for. Urban VIII ascended to the papacy. Galileo had known Urban VIII, born Maffeo Barberini, for years and considered him a friend. Urban VIII did admire much of Galileo’s work, though he still held to the church doctrine favoring geocentrism. However, Galileo approached Urban to see if he could obtain permission to publish. The two discussed the issue at length and while Galileo failed to convert Urban to heliocentrism, Urban did tell Galileo that the heliocentric view could be discussed hypothetically, if presented as one of many possible views for the cosmos.

Cover to Galileo's Dialogues. "Dialogues" by Rhubarble is licensed under CC BY-NC 2.0;

Seizing on this, Galileo published his arguments for heliocentrism in the form of a dialogue. In his work, *Dialogue Concerning the Two Chief World Systems*, three Italian gentlemen discuss the cosmos over dinner. Sagredo, the host, is initially neutral while Salviati argues in favor of the Copernican model. Meanwhile, Simplicio (the fool), argued for Aristotle and Ptolemy's geocentric view. Salviati clearly had the stronger argument of the two while Simplicio made only simplistic points. Galileo made a tactical error, however, when he incorporated some of the statements Urban VIII had made in their earlier discussions. Believing Galileo had deliberately satirized him, Urban VIII turned his back on Galileo. The inquisitor put Galileo on trial. Knowing the fate of Giordano Bruno, Galileo recanted his support for heliocentrism rather than face torture and execution. The inquisition put him under house arrest for the rest of his life and forbade him from every publishing about astronomy again.

Instead, Galileo returned to some of his earlier studies on motion. Using an inclined plane, he studied the motion of balls as they rolled downhill. From his timing of these balls, Galileo determined that all falling objects experienced that same acceleration from

Earth’s gravity, regardless of their weight. His final work on motion would be refined by Isaac Newton as he formulated his laws of motion and law of gravity.